Name _Key_____ AP Chemistry

Gas Stoichiometry

Practice Problems:

1) Calculate the average molar mass of dry air if it has a density of 1.17 g/L at 21°C and 740.0 torr.

$$d = 1.17\ \frac{g}{L};\ P = 740.0\ torr = 0.97\ atm; T = 21°C = 294\ K; R = 0.0821\ {}^{Latm}/_{Kmol}$$

$$MM = \frac{dRT}{P} = \frac{\left(1.17\frac{g}{L}\right)\left(0.0821\ {}^{Latm}/_{Kmol}\right)(294\ K)}{0.97\ atm} = 29.1\ g/mol$$

2) In the first step in the industrial process for making nitric acid, ammonia reacts with oxygen in the presence of a suitable catalyst to form nitric acid and water vapor:

$$4\ NH_3\ (g) + 5\ O_2\ (g) \rightarrow 4\ NO\ (g) + 6\ H_2O\ (g)$$

How many liters of NH_3 at 850°C and 5.00 atm are required to react with 1.00 mol of O_2 in this reaction?

$$\left(\frac{1.0\ mol\ O_2}{1}\right)\left(\frac{4\ mol\ NH_3}{5\ mol\ O_2}\right) = 0.80\ mol\ NH_3$$

$$P = 5.00\ atm; T = 850°C = 1123\ K; R = 0.0821\ {}^{Latm}/_{Kmol}$$

$$V = \frac{nRT}{P} = \frac{(0.80\ mol)(1123\ K)\left(0.0821\ {}^{Latm}/_{Kmol}\right)}{5.00\ atm} = 14.8\ L$$

3) A student adds 4.00 g of dry ice (solid CO_2) to an empty balloon. What will be the volume of the balloon at STP after all the dry ice sublimes (coverts to gaseous CO_2)?

$$\left(\frac{4.00\ g}{1}\right)\left(\frac{1\ mol}{44.01\ g}\right)\left(\frac{22.4\ L}{1\ mol}\right) = 2.03\ L$$

4) Sulfur trioxide, SO_3, is produced in enormous quantities each year for use in the synthesis of sulfuric acid:

$$S\ (s) + O_2\ (g) \rightarrow SO_2\ (g)$$

$$2\ SO_2\ (g) + O_2\ (g) \rightarrow 2\ SO_3\ (g)$$

What volume of O_2 at 350°C and a pressure of 5.25 atm is needed to completely convert 5.00 g of sulfur to sulfur trioxide?

$$S\ (s) + O_2\ (g) \rightarrow \cancel{SO_2\ (g)}$$

$$\underline{+\ \cancel{2}\ SO_2\ (g) + O_2\ (g) \rightarrow 2\ SO_3\ (g)}$$

$$S\ (s) + SO_2\ (g) + 2\ O_2\ (g) \rightarrow 2\ SO_3\ (g)$$

$$\left(\frac{5.00\ g\ S}{1\ mol}\right)\left(\frac{1\ mol}{32.06\ g}\right)\left(\frac{2\ mol\ O_2}{1\ mol\ S}\right) = 0.312\ mol$$

$$P = 5.25\ atm; T = 350℃ = 623\ K; R = 0.0821\ {}^{Latm}/_{Kmol}$$

$$V = \frac{nRT}{P} = \frac{(0.312\ mol)(0.0821\ Latm/Kmol)(623\ K)}{5.25\ atm} = 3.04\ L$$

5) (a) Calculate the density of sulfur hexafluoride gas at 678 torr and 28°C.

$$P = 678\ torr = 0.892\ atm; T = 28℃ = 301\ K; R = 0.0821\ Latm/Kmol; MM = 146.06\ g/mol$$

$$d = \frac{PMM}{RT} = \frac{(0.892\ atm)\left(146.06\frac{g}{mol}\right)}{\left(0.0821\ {}^{Latm}/_{Kmol}\right)(301\ K)} = 5.27\ g/L$$

(b) Calculate the molar mass of a vapor that has a density of 7.135 g/L at 12°C and 743 torr.

$$d = 7.135\ \frac{g}{L};\ T = 12℃ = 285\ K; P = 743\ torr = 0.98\ atm; R = 0.0821\ {}^{Latm}/_{Kmol}$$

$$MM = \frac{dRT}{P} = \frac{\left(7.135\frac{g}{L}\right)\left(0.0821\ {}^{Latm}/_{Kmol}\right)(285\ K)}{0.98\ atm} = 170\ g/mol$$